

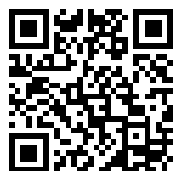
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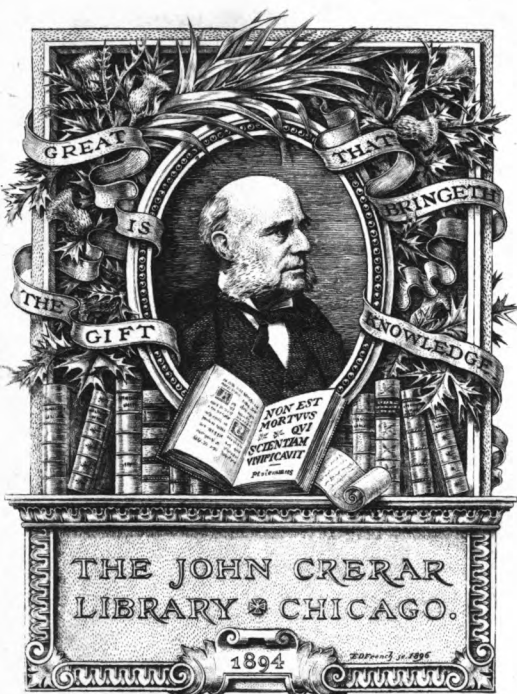
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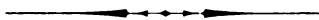




THE ESTATE OF ROBERT FORSYTH



THE
BOWER-BARFF
Rustless Iron Company.



OFFICES:

NO. 35 BROADWAY, NEW YORK.

1883.



THE
BOWER-BARFF RUSTLESS IRON COMPANY.

CAPITAL, - - - \$750,000.

Directors.

GEO. W. MAYNARD, Mining Engineer.

ROSSITER W. RAYMOND, Ph. D.

CHAS. C. DODGE, late of PHELPS, DODGE & Co.

HERMAN KOBBE.

NIELS POULSON, of the Hecla Iron Works.

JOHN BOWER, of Rochester.

Officers.

GEO. W. MAYNARD, - - - - - *President.*

CHAS. C. DODGE, - - - - - *Treasurer.*

HERMAN KOBBE, - - - - - *Secretary.*

R. W. RAYMOND, Ph. D., - - - - - *Consulting Engineer.*

Solicitors.

KOBBE & FOWLER.

THE BOWER-BARFF RUSTLESS IRON PROCESS.

THE value of the Process has been thoroughly and satisfactorily demonstrated in this country by a three months' trial at the Hecla Iron Works in Brooklyn, E. D., as is shown by the following letter :

POULSON & EGER,
HECLA AGRICULTURAL IRON WORKS,
North 11th and Third Sts.

BROOKLYN, E. D., N. Y., June 1, 1883.

Prof. GEO. W. MAYNARD, 24 Cliff Street.

DEAR SIR :—We take great pleasure in expressing to you our satisfaction with the results obtained from the Bower-Barff Furnaces erected in our works. The furnace adapted for cast iron has now been running continuously for four months, and the coating of the magnetic oxide has been uniformly good. We have subjected articles treated in the furnace to the severest tests, and they fail to show the slightest tendency to rust.

In the matter of ornamentation of the iron, we are very much pleased with the success of the process, and we have been able to produce excellent effects with polished surfaces. We are confident that in this direction it has opened up a new field for ornamental iron work that will prove of great value to us.

We also take great pleasure in reporting that all Architects, Engineers and iron men to whom we have so far shown samples of coated work, have uniformly expressed satisfaction with the process, and we have reason to believe that they will give every encouragement to its adoption for building and ornamental purposes.

Very respectfully yours,

POULSON & EGER.

Some of the finest architectural iron work in New York City is from the shops of Messrs. POULSON & EGER. The most conspicuous work lately constructed by them is the East River Bridge Station on the Brooklyn side, a portion of which has been treated by the Rustless Process. They are also treating the great stairways, consisting of fifteen flights, and the other interior iron work of the *new Produce Exchange*, and they have other large orders on hand.

The following establishments have already taken licenses and furnaces are being constructed :

THE HECLA ARCHITECTURAL IRON WORKS, oxidizing chamber 13 ft. \times 4 ft. \times 4 ft., in operation for four months ;

THE TRENTON IRON WORKS (Messrs. COOPER HEWITT & Co.), size not determined ;

THE AMERICAN SHIP BUILDING COMPANY of Philadelphia, oxidizing chamber 22 ft. \times 14 ft. \times 6 ft ;

THE ABENDROTH AND ROOT MANUFACTURING COMPANY, oxidizing chamber 28 ft. \times 10 ft. \times 10 ft.

In the latter furnace it is proposed to coat one mile of wrought-iron pipe a day.

Licenses with many other prominent firms are about being concluded. Subsidiary companies are being formed in different States.

Within the past few months the Process has had a rapid development in England and France. At one works in Paris there are seven furnaces, the two largest being thirty-six feet long by six feet six inches wide and six high. These furnaces are used for coating large water and gas pipe.

The following English works have furnaces in operation :

WALTER MACFARLANE & Co. of Glasgow, who manufacture 100 tons of architectural iron a day.

MESSRS. JOHN RUSSELL & Co., Alma Works, Walsall.

“ DEWRANCE & Co., Borough.

“ HORN, BLACK & Co., Old Kent Road.

“ SPENCER TUBE WORKS, West Bromwich.

“THE MIDLAND RUSTLESS IRON COMPANY,” of Wolverhampton.

GEORGE BOWER, at St. Neots, Huntingdonshire.

“THE BOWER-BARFF RUSTLESS IRON COMPANY,” in London.

Furnaces have also been erected at Sunderland and Liverpool

The Process is applicable to all forms of cast and wrought iron and steel where the surfaces are not subjected to very severe friction. It will supplant the expensive and usually unsatisfactory galvanizing, and for culinary utensils will take the place of tinning and enameling. Enamelling works have adopted the process, because it is found by first oxidizing the enameling is much simplified and reduced in cost. Works for combining the two processes have been established in Bavaria.

The very objectionable lead pipes for plumbing are giving way to the clean and innocuous magnetic-oxide pipes.

The widest use of the Process will undoubtedly be for the coating of architectural iron work, and for gas and water pipe, and ship work. It must greatly increase the use of iron for structural purposes, and will be a boon to the architect, who will thus have an opportunity of introducing ornate and florid designs to an extent which would on account of the great cost be impossible in stone or other building material.

Up to 1876, when Prof. BARFF announced in the London *Times* his method of coating wrought iron surfaces with magnetic oxide, this coating had not been produced designedly other than on Russia sheet iron by a very expensive process. The scale of the rolling mill is a magnetic oxide, but of no value as a preservative, because non-adherent.

Prof. BARFF's method, while well adapted to wrought iron, was found to be too slow, and in other particulars too expensive for ordinary castings. That the Process has been brought to the present degree of excellence and cheapness is due to ingenuity and perseverance of the Messrs. BOWER of St. Neots in England.

The first detailed account of the Process was given in the paper of Mr. GEO. BOWER, read at the annual meeting of the Iron and Steel Institute in 1881.

Particular attention is called to the discussion of this paper by such eminent authorities as Sir JOHN ALLEYNE, JEREMIAH HEAD, Prof. HUNTINGTON, and JOSIAH T. SMITH, the then President of the Institute and General Manager of the Barrow Hematite Steel Works.

ON THE PRESERVATION AND ORNAMENTATION OF IRON
AND STEEL SURFACES.

BY MR. GEORGE BOWER, ST. NEOTS, HUNTINGDONSHIRE.

Any process which has for its object the preservation of iron and steel from rust, and which will make these metals more applicable than they now are to the requirements of mankind, will be sure to meet with attention from members of the Iron and Steel Institute, and from all those who are either engaged in their production or application.

It is, perhaps, not too much to say that with iron and steel rendered secure against corrosion and decay, they will be used to an infinitely greater extent than they now are. The whole realm of science has therefore been explored in the attempt to discover some method by which the formed article may be preserved, leaving its strength undiminished by the destructive action of rust.

Paints, oils, varnishes, glazes, enamels, galvanizing, electro-depositing, and what is called "inoxidizing," are among the many systems now in vogue to effect the preservation of iron and steel from the corrosive action of air and water.

The object of this paper is to show what may be done in protecting iron and steel from rust by forming upon their surfaces a film of magnetic oxide by an inexpensive process.

It is no new thing to be told that magnetic oxide of iron is unaffected by exposure to the atmosphere; hence it is that so many people have endeavored to produce magnetic oxide paints from red oxide of iron or from natural magnetic oxide itself.

Dr. PERCY has pointed out that the reason why Russian is less affected by exposure than English sheet iron is because of a coating of magnetic oxide; but this was not known until Dr. PERCY discovered it. That such a coating is produced is quite certain, but it is only an accident of manufacture.

To Professor BARFF is due the credit of being the first to deliberately undertake to coat iron and steel with magnetic oxide, produced *designedly* for the purpose of protecting their surfaces from rust. For my own part, whatever I may have done in the same direction, I feel it only right to publicly acknowledge that if the Professor had not made his discovery, I greatly question whether I should have ever attempted anything of the kind.

It is curious how nearly we approach to discoveries without grasping them. Some sixteen or seventeen years ago, I was making a series of experiments in the production of heating gases, one set of them being the decomposition of water by passing superheated steam through masses of red iron. I observed that the iron became less and less active until it ceased to decompose at all, when, on examining it I noticed that it was coated with a kind of enamel. It at once occurred to me, on seeing this, that the process in question might be used to obtain such a coating; but I found, after a few days' exposure of the iron to the atmosphere that the coating shelled off, and I pursued the matter no farther.

I now know that if the iron had been new instead of rusty, I should have been the accidental author of the process which Professor BARFF discov-

ered ten years afterwards. I only mention this to show how advisable it is to investigate the causes of unexpected effects. Out of such investigations, if we do not obtain the philosopher's stone, we may at least discover a very bright pebble.

Professor BARFF's process consists in subjecting iron and steel to the action of superheated steam, and when they are at a temperature sufficiently high, the iron then seizes the oxygen, and the product of the union is magnetic oxide.

Here I feel bound to say that it was only on reading the description of the process that appeared in the *Times* in the early part of the year 1876, that it occurred to me that what the Professor could effect with water I ought to be able to effect with air, even though the oxygen in the one was in chemical, and in the other in mechanical combination.

An experiment was accordingly made with cast iron, and it was successful; but repeated experiments made afterwards turned out to be unsuccessful. Instead of getting magnetic oxide, I got sesquioxide in the most provoking and unaccountable manner.

In the end, however, it was discovered that the quantity of air to be admitted into the closed retort, muffle, or chamber, must bear some proportion to the surface of the iron under treatment; for if an excess occurred, red oxide was sure to be formed.

The main principle of action was to admit a few cubic feet of air into the chamber every half hour, during which time the iron had taken up the oxygen it contained, and a coating of magnetic oxide was formed, which increased in thickness by every successive operation. Effective as this was for cast iron, the cost of producing the coating was as great as by the BARFF process, for both of them required that the chamber should be heated by the external application of heat, and this, with large chambers, was very expensive.

It then occurred to my eldest son that we ought to be able to heat the articles by the *internal* application of heat, and to coat them at the same time by oxidizing and deoxidizing operations.

A long series of very costly experiments was thereupon commenced, extending over a couple of years, the result being that we now proceed as follows: A fire-brick chamber of any suitable dimensions is formed, in which the articles to be coated are placed, and connected with, which is a set of gas producers. The gas, as produced, is led along passages, and is there mixed with air in a highly heated condition and consumed. The product of combustion—carbonic acid—and a small quantity of free air, enter the chamber, and are partially denuded of oxygen by their contact with the heated articles. They then pass over a fire clay regenerator, which heats the air both for the purpose of combustion and also for oxidizing.

It will thus be seen that solid fuel of the cheapest kind may be used and converted into carbonic oxide, which, on being consumed as described with a sufficient quantity of air, leaves carbonic acid as the product; and it, together with highly heated air, passes into the chamber, making the articles red hot, and in that condition they take up oxygen both from the carbonic acid and from the air.

The effect of this is the production of a coating of magnetic oxide incorporated with the surface of the iron, but over it there is also formed a film of sesquioxide.

This part of the process occupies about half an hour, and is the oxidizing operation. The air valve is then shut off and carbonic oxide is let into the chamber, which reduces the upper coating of sesqui- into magnetic-oxide.

This is the deoxidizing operation, and it occupies about a quarter of an hour.

The whole process, consequently, consists in a series of oxidizing and deoxidizing operations, and the thickness of the coating on the metal depends upon the number of such operations. For indoor work, from two to four hours are sufficient ; for outdoor, an hour or two longer is required.

One of the most interesting features of this process is that rusty iron, when subjected to the deoxidizing process, has its rust converted into a thoroughly protective coating. All that is necessary for this purpose is to remove the loose scale of rust from the iron before it is put into the furnace. Specimens of iron so treated are exhibited.

Not only, however, does this magnetic oxide coating process protect from rust, but the coating is of such a beautiful color as to render articles ready for the market directly they are out of the furnace and cooled. One remarkable feature of it is, that there is no more cost (except in the labor of handling them) in treating 2,240 articles, each weighing a pound, than there is in coating a cube of metal weighing a ton ; and so penetrating is the process, that no matter how intricate the pattern may be, every crevice, which it would be almost impossible to get at with a paint brush, is as effectively coated as the plainest surfaces, as will be observed by examining the specimens exhibited in this room.

For art purposes the French gray color with shades approaching to black might not always be suitable, but if it should be necessary to use paint on the iron so coated, there is the absolute certainty that it will remain on in the same way as it does on wood or stone, and thus iron may be used for constructive work in a thousand directions in which it has not up to the present time been possible on account of its liability to rust, no matter what the coating used to protect it has been. I can give an instructive instance of this. A company in Paris had expended a very large sum over Dodé's inoxidizing process, which process consists in the depositing of successive layers of lead or silicate coatings on iron and steel, and then gilding, platinizing or bronzing them ; and certainly the articles so treated were exceedingly pretty to look at ; but the iron ultimately rebelled and threw off the coatings, so that the shareholders were in a fair way of losing all their capital, when it was suggested to the directors that if their compositions could be deposited direct upon magnetic oxide they would conquer the difficulty. They then applied to me for specimens of coated iron to experiment upon, and they were so satisfied with the result that the company purchased all my Continental patents, and now intend to carry on the combined processes on a large scale. By the kindness of the French company I am enabled to exhibit here to-day specimens of their work.

Professor BARFF's is better than mine for wrought iron, and as I could see my way to construct a furnace that would combine my own process with

the Professor's, I have purchased the whole of his patents, wherever existing.

The difference in the cost of working the two processes when worked *separately* is very great—the BARFF process requiring, as it does, the external application of heat to the muffle or chamber, which, if of any considerable dimensions, is both difficult and very costly ; but besides this a separate steam boiler is required, and a separate superheater, so that three distinct operations are necessary.

By a newly constructed furnace, which combines both the BARFF and my own systems, we can now coat by either at pleasure.

The furnace for these combined operations I am not in a position to explain, as the patents are not yet completed.

Engineers and manufacturers appear far more ready to apply the processes on the Continent than up to now they have been here ; but perhaps the reason has been that, so far as Professor BARFF's process is concerned, it has not been yet shown how large masses can be dealt with. I am able to demonstrate this, and to show also that for the treatment of underground pipes, wrought iron sleepers, roofing and the like, the process can be readily applied, and at a cost much less than that of galvanizing, and it will at the same time be infinitely more durable ; while for ornamental cast and wrought iron it is scarcely possible to imagine anything more artistic in color than some of the articles after they have been treated. I hope also to be able to color the magnetic oxide at a cheap rate, so that the field of operations for art work will be a very wide one. For ordinary hollow ware for kitchen use, whether of cast or wrought iron, this process is admirably adapted ; and though I am told that the gray or black color will probably be objectionable, yet I imagine, if it can be shown, as we can do, that the magnetic oxide coating is more durable, more easily cleaned, and *much cheaper* than even the common tinned article, a market will soon be created. Anyhow, the now combined processes are so far developed, and they have been so thoroughly examined by scientific and practical men both here and on the Continent (whose testimony to the value and efficacy of them is voluminous), that they have passed from the region of theoretical investigation into that of practical application, and means will be immediately taken for establishing works in different centres of Great Britain for the purpose of coating iron and steel as a trade operation.

I am intending to apply the process to cast iron gas and water pipes, and as the former have comparatively no pressure to bear, they may be made much lighter than they now are if rendered incorrodible ; while for water, it will be a great advantage to have both the main and service pipes rendered safe from rust, which not only discolours the water, but forms the nucleus of very troublesome deposits. I expect also to be able to supply wrought iron or mild steel pipes for the same purposes, especially for the interior towns of distant countries, where the first cost of the pipes is but small as compared with the cost of carriage. I have myself used gas and water pipes where the cost on arrival at their destination has been five times greater than their first cost in England.

If, then, light wrought iron or steel pipes could be used, not weighing one-third of those made of cast iron, and rendered practically indestructible,

what an enormous saving will be effected ! Again, in the case of railway sleepers in iron and steel, which are now almost wholly used in Germany, the process is likely to prove of much advantage. So, at least, I am told by eminent engineers both in Belgium and in Germany ; and if there, why not here ?

It will naturally be asked, what is the cost of the process ? I cannot do better than answer this question by quoting from the report of Professor FLAMACHE, the engineer-in-chief of the State railways in Belgium, who was sent over specially to report on the process for the Public Works Department of that country at the end of January last. His estimate of cost, after a very careful examination and testing of the process, was $7\frac{1}{2}$ francs per 1,000 kilos., or about three-fourths of a centime per kilo., and by the surface, three-eighths of a centime per decimeter cube, but, he adds, ' This cost may be reduced ; as instead of one workman attending only to one furnace, he can attend to three or four ; also by a better system of taking the articles in and out than existed in the experimental furnace I saw at St. Neots, and by having one gas producer only for several chambers.'

Of course the above cost is exclusive of royalty. In the combined processes, which will hereafter be called the BOWER-BARFF process, the cost will be somewhat greater, but not much ; and we shall be able to oxidize with carbonic acid and air or superheated steam, and to reduce rusty iron with carbonic acid at pleasure.

Sir JOSEPH WHITWORTH, feeling much interested in Professor BARFF's process, sent to him some steel to be oxidized, so that he might ascertain whether it did or did not lose in strength by the operation ; and the result of Sir JOSEPH's testing was that there had been no alteration whatever. Theoretically, one would rather expect that iron and steel would be somewhat toughened, as the tendency of the process is to anneal, and would, no doubt, if continued long enough, render some classes of cast iron malleable.

The development of these processes has been a very long and tedious business, and one requiring much faith and patience in the midst of most disheartening failures for months together ; but to gentlemen connected with the iron and steel industries, who know well that results are only obtained by patient and well directed toil, I need not dwell on this, as almost every man who has had to reduce theory to practice has had abundant experience of the same kind.

DISCUSSION.

Dr. SYSON said that he had had the opportunity of watching and criticising the BOWER process for some years. He had seen Mr. BOWER's failures, and now he was happy to say that he had seen his successes. The paper hardly did that gentleman justice. Mr. BOWER had alluded to the color of the specimens shown. Well, that color, especially in this æsthetic age, seemed to be one of its grandest and most artistic properties. As to its durability, he had seen specimens which had been in use for months and years without any detrimental effect upon their condition. There was one new feature which had hardly been sufficiently explained with regard to the ornamental application of the process. He himself was interested in the process more from a sanitary than from a general or civil engineering point of view ; for it was evident that if

they could get iron that would not corrode, it would give them a great advantage for sanitary purposes, where they could use a material which was practically lasting, but which would not rust. If they found that to be so, a great amount of sanitary trouble would be done away with, because if they showed the advantages of it to owners of property, the process would certainly be adopted. Mr. BOWER had come before them not with a mere theoretical novelty, but with a process which was in full swing, and perfected. The ornamental articles made by this system would, he thought, become generally popular. Mr. BOWER seemed to have given a good deal of time to explaining away the so-called prior claims of Russian iron, but no one would think of comparing the exceedingly imperfect coating which Russian iron got by accident with the beautiful and perfect productions which they saw before them.

Mr. P. F. NURSEY said he had known Mr. BOWER's process for about three years, but it was two years before Mr. BOWER could get him to look at it. Mr. NURSEY had, however, had some specimens hanging in his garden for seven or eight months, including the winter of 1879-80, and on examining them carefully he found that they had suffered no detriment at all. Indeed, on comparing them with the specimens which he had in the house they looked rather brighter and cleaner after washing. He had visited Mr. BOWER's works and had seen the process eight or nine months ago. He was of opinion that it was commercially satisfactory. He had seen a batch of iron articles put into the furnace and drawn out at a given time, and the results were most satisfactory—such, in fact, as were shown by the samples on the table. When Professor BARFF's process was brought before the Institute, Mr. NURSEY raised the question as to whether its application might not act injuriously upon the metal to weaken it, and so render it unsafe for structural purposes. He observed, however, in Mr. BOWER's paper that some WHITWORTH metal had been subjected to BARFF's process, and on being afterwards tested, gave the usual satisfactory results. It now remained for Mr. BOWER to submit iron and steel treated by his process to similar tests to establish its value with regard to roof and bridge work and other constructive applications. The only remaining question would be the capacity of the furnace required for such large articles, but that difficulty could easily be overcome. From his knowledge of the process and its results he considered it had a great future before it, both from an engineering and a decorative point of view.

Mr. MICHAEL SCOTT asked whether Mr. BOWER would tell them about the application of the process to railway purposes, and to work on a large scale generally.

Sir JOHN ALLEYNE said that there were some points of especial value in the process that Mr. BOWER had introduced to the notice of the Institute. They saw on the table specimens of deck beams and other articles. He had been engaged for many years in the manufacture of those beams, as well as of rolled girders and similar goods. In making such articles it was impossible to avoid having large stocks on hand, not only with a view to meet the demand of purchasers of small quantities, but because it frequently happened that when, for example, there was an order in hand for beams, say 40 feet long, some few would not hold up and had to be cut to 36 or 38 feet. Now those bars were put

into stock. It would not do to paint them, because the purchasers would say that they were puttied and painted to hide defects, and would therefore refuse them. It would not do to warehouse them, because the cost of getting such things in and out of a warehouse would be too great; and even then they would rust. Such stock indeed rusted badly in a short time; it became pitted with rust, and it was then objected to on that account. He had himself on many occasions been obliged to cut up a lot of valuable stock in consequence of its depreciation from this cause. The Iron and Steel Institute might congratulate itself on having such a beautiful process worked into practical shape by one of its members; and he was pleased that that member was Mr. BOWER, with whom he had had business correspondence for many years. Mr. BOWER had come to relieve them from a great difficulty, even were his process confined to the stocks of iron in hand; but when they considered to how many useful purposes it might be applied, it could not be appreciated too highly. Take, for instance, such a structure as St. Pancras Station. He well remembered the difficulty that existed in that case, where it was necessary to move the staging before the work could be painted. If the staging were not moved back other staging must be provided to follow up with the paint. The Midland Company had lately painted the ironwork of this roof, a work of no small difficulty and expense when it was considered that it is 100 feet from the floor girders to the top, and 240 feet span. Now, Mr. BOWER, by putting on a beautiful coat of magnetic oxide before erecting the work, would let them out of all such difficulties. There were however, some points that required inquiry. The Admiralty had lately issued instructions for the removal of magnetic oxide, formed, he supposed, during the process of rolling; and he should like to ask Mr. BOWER whether the particular oxide formed by his process was likely to set up galvanic action with the iron coated? He should also like to know whether specimens so coated had been subjected to the action of sea water? If the process could be used for coating the bottoms of iron ships, it would indeed be of great value to our shipbuilding friends and the whole country.

Mr. J. HEAD said he was afraid the outside public would accuse their Institute of inconsistency. It had been said in that room only two days previously, that the great thing was to get rid of magnetic oxide from the surface of the iron used in ships and boilers. Now they were told they should do their utmost to put magnetic oxide on to the iron. They were all interested very much in protecting heavy structures from oxidation. Anything like fine painting was very much wasted upon iron roofs, columns and other structures. For instance, the handsome station built at York four years since had been elaborately painted, but ere long the rust had broken through the paint in all directions and entirely destroyed the effect. They were now repainting it at a cost of something like £2,000. That would give them an idea of the need of something of a more permanent character in protecting iron structures. He could name another instance, and that was the high level bridge at Newcastle. It was mainly of cast iron, and was exposed to an unusually corrosive atmosphere. He remembered noticing, when he used to pass twice a day over that bridge, some years ago, the trouble that there was in keeping it properly painted. At first they tried stone color, but the rust struck through in no

time, and at last they found it best simply to tar it. There was merit about this invention, and that was its application to corrugated wrought iron sheets, which were used instead of slates for roofing. That kind of covering was lighter, and it was more easily dealt with in many respects than slates. In strong winds which got under open roofs, slates were blown away like a flock of crows. That did not happen with corrugated sheets. Whether they were galvanized or painted one, two, or three coats of paint, it seemed just the same as regards permanent protection. For all alike were soon useless. The best plan which he knew of at the present time was to cover them with tar thickened with chalk, and that required renewing once a year. If the specimens they saw before them could be put into a furnace, such as had been indicated, and coated with an oxide like that exhibited, and it came out as well in practice as the author of the paper promised, it certainly would be a wonderful advantage in many cases. After thick masses of iron coming through the rolls had lain hot in the atmosphere for some time, there was always a blue scale formed, which fell off and again formed till the iron was too cold. If sections of iron, of a thinner iron, were rolled—plates $\frac{1}{4}$ to $\frac{3}{8}$ thick, they found that they always came out red. This difference seemed to arise from the different temperature at which thick and thin plates were finished. Although the paper which they had just heard was not a pretentious one, it was likely to be, in his opinion, one of the most valuable which had ever been read before the Institute.

Professor HUNTINGTON remarked that a great share of the credit of perfecting this process was due to Mr. BOWER's son; for it was admitted that in point of economy there was no gain over Professor BARFF's method until the system of heating the articles to be coated inside the chamber was introduced. It was not until this was done that the process became a commercial success. With regard to what Mr. HEAD had said about coating wrought iron for roofing purposes, Professor HUNTINGDON pointed out that wrought iron invariably contained slag diffused through it, and that the coating of magnetic oxide would not form wherever the slag existed on the surface—this would eventually cause pitting at those points. A somewhat similar thing occurred sometimes in tinning steel; if the steel contained too much silicon the tin would not take. This was due to a film of silica forming on the surface. For the BOWER process soft steel would be superior to wrought iron, as, having been in fusion, it was free from slag. As regards the risk of galvanic action occurring at the rivet holes, it would probably be practicable to prevent that by drilling the holes first and then forming the oxide, which had no tendency to chip off if it had been properly formed.

Mr. G. R. TWEEDIE, F.C.S., said that having had unusual opportunities of following Mr. BOWER's process, he would like to say a few words. They all saw from the specimens exhibited the pretty effect of the gilt and bronze on the various articles. The surface of the articles was first coated with magnetic oxide, and gold, or platinum, or silver, or whatever metal was chosen, was mixed up in the form of chloride with certain essential oils, and then placed upon the articles in a wet state and put into the furnace for a few moments, when the metallic surface quickly developed. With regard to the action of corrosion by liquids and vapors on the surface of iron, he had

had several opportunities of testing this matter, and he had had a number of specimens treated with acids of different kinds—hydrochloric and sulphuric of different strengths. He found that the iron resisted, but when not coated well it came away. They could hardly hope to have the process adopted in chemical manufactories. With regard to ammonia vapor, he might say the iron resisted it, but an ordinary thin coating was not sufficient to resist for a great length of time. Soda and potash solution was resisted fairly well, according to the strength of the liquid or the thickness of the oxide. The weaker liquids had no effect, but the stronger solution worked through it slowly. The peculiarity of having magnetic oxide on the surface of iron was this: If they broke away the surface, they found that the rust was confined to that spot. There was no tendency to "lateral" rusting as in the case of painted surfaces, but the tendency was to confine it to where the oxide had broken off. There was a great advantage in this respect over other methods of protection, for although the oxide might be chipped in places, corrosion was strictly localized. He might add his tribute to the indomitable perseverance of Mr. BOWER during the long period in which he had pursued that investigation. In the early days of the process the results were most discouraging. Articles came out to which they gave the technical name of "lobsters" (from their bright red color), but such a thing as a "lobster" was quite unknown now, as they got the articles in the way that they saw them on the table, and Mr. BOWER hardly knew what it was to obtain an unsatisfactory result.

Mr. BARFF said that he had been desired by his father to express the regret he felt at being unable to be present to hear Mr. BOWER's paper. Mr. BOWER had his cordial sympathy and good wishes in the matter which was now before them. For wrought iron he believed that the BARIFF process had the advantage. It had been stated that there might be a difficulty in getting the magnetic oxide on the surface of wrought iron; not only was that not the case, but they had found invariably that the surface of wrought iron was transformed into one of magnetic oxide with much more certainty and readiness than cast iron. The difficulty with cast iron was that they could not, owing to the formation of their particular apparatus, get sufficient heat to thoroughly oxidize the cast iron. The question of galvanic action had been frequently raised. They had submitted the question for investigation, and they had obtained two diametrically opposite opinions, one of which had come from a very eminent chemist, who said he did not consider that there was any galvanic action. This was their idea also; and that a piece of iron of which part was oxidized and part not, rusted no faster than a wholly unprotected piece would, each being immersed in sea water. The contrary opinion was expressed by the Admiralty authorities at Portsmouth, but he could not state how their experiments were conducted. The point which Mr. TWEEDIE had touched upon was a most important one. Where they abraded the surface, there rust appeared, but it did not extend laterally, throwing off magnetic oxide on either side. They had had specimens, from which the coating had been partly removed, placed in sulphate of copper solution; a hole was eaten right through the tube where unprotected, the magnetic oxide remaining all round the surface of the hole as adherent as when first put into the solution.

Professor HUNTINGTON said he had not stated that steel could be more easily coated than iron. He believed the contrary would be the case ; he had simply pointed out the objection to using the latter owing to the slag it contained.*

Mr. BOWER said that his labor in replying had been very much lessened by the remarks of the gentlemen who had spoken. He should, however, have to notice some of the observations made in the discussion. Mr. SCOTT had asked what was the limit of the size of the work that could be treated. His reply to that was, that it was ilimitable under the present mode of procedure. It had been very limited indeed so long as the chamber had to be heated by the external application of heat, but now that they could heat by an internal application, the difficulty had been entirely removed. The heat of the superheated steam, air, or carbonic acid gas must always *command* the temperature of the articles inside. He had been asked about the ornamental portion of the work exhibited, but the question had been answered by Mr. TWEEDIE. The theory of his coating processes had been submitted to two eminent chemists in Paris, and after they had reported favorably, two practical men and a chemist were sent to St. Neots from there. Those gentlemen remained at his works about a week, and the result was that his patents for the Continent of Europe were purchased by a French company. With regard to the observations of Sir JOHN ALLEYNE, and the advantage of being able to keep new iron in stock free from rust if it were previously treated by his process, he might say that there was a further advantage which he claimed, and that was, that if the iron were rusted, the rust itself could be converted into a rust-proof covering of magnetic oxide, and he could point with satisfaction to a specimen on the table in proof of his claim. In answer to another question of Sir JOHN ALLEYNE'S with respect to the effect of temperature on the coating, he had to say that at whatever temperature the coating was produced, the article might be subjected to any below it, and it would not be affected. He had made articles red hot, and plunged them into cold water, and they had not been affected. Mr. HEAD expressed some surprise at having heard a paper read on a previous day on the relative degrees of corrosion between steel and iron, and that no reference had been made to the fact that there had been his own and Professor BARFF'S processes in operation for a considerable time, the object of which was to prevent corrosion entirely. Surely *prevention* was the thing to be aimed at. With regard to what had been stated on Wednesday on galvanic action, he should like some one to show him that there was galvanic action with a perfect coating of magnetic oxide. Scale was one thing, and magnetic oxide, as produced by him, was another. He was much obliged to Professor HUNTINGTON for what he had said about him and his son. He was much pleased, and not a little proud that the success of the process was very much due to his son's skill and perseverance. The Professor had stated that it would be very necessary to have the slag taken out of the iron, for if there were any on the surface, the coating would be imperfect. Slag on iron surface was the exception, but he had not observed that this in the least degree affected the continuity of the

* Professor HUNTINGTON informs us that a case in point has since come under his notice.—ED.

coating. If any of the magnetic oxide were chipped off by any means, he found that the rust was absolutely confined to that point. In the course of time he expected to be able to deal with that which some gentleman in the body of the hall stated would be a great benefit, the coating of ships' plates, and he hoped to apply superheated steam *in situ*, so as to get a thin film of magnetic oxide even over the rivets and the rivet holes after the riveting operation had been performed. Sir HENRY BESSEMER, by the application of oxygen in air, denuded crude iron of part of its carbon and converted it into steel, and he hoped by another application of oxygen to convert the *surfaces* of both iron and steel into magnetic oxide, so that there should be no corrosion on them, and thus the *substance* of the material would be protected from rust and decay. The process had gone from the domain of experiment into the region of practical work, and he trusted that he would be considered as one who was endeavoring to render the iron and steel industry more prosperous than it was now, or than it had hitherto been.

The President said that it was a source of great regret to have to close that discussion in the absence of Dr. PERCY, for there was no gentlemen whose opinions and observations were treated, he might almost say, with so much reverence as those of Dr. PERCY. The subject had been fully discussed, and he thought they would come to the conclusion that the field of operations to which this new system could be applied was almost illimitable. If the process could be carried out as some of them anticipated, he had no doubt they would have that subject very often before them again. He had to ask them to record a vote of thanks to Mr. BOWER for his very valuable and interesting paper, which was unanimously accorded.

Mr. BOWER, in reply, asked leave to notice, what he had omitted to do before, that some gentlemen had asked about the effect of salt water on the iron, as to which he might give them the testimony that had been received from a gas-work manager in Brazil, who had some tubes coated by Professor BARFF's process. Those tubes were buried in sand on the seashore for nearly two years, and when removed some months since were free from rust. From Dr. PERCY he had received every possible encouragement, and it was at that gentlemen's suggestion that the paper had been read. Dr. PERCY had told him only on Wednesday to go to the House of Parliament, where some specimens of coated iron had been placed in the open for about twelve months, and which were as perfect now as when they were first exposed.

The next important contribution to the literature of the subject was by Mr. ANTHONY S. BOWER in his paper read before the "American Institute of Mining Engineers" at their annual meeting in Boston, February, 1883.

THE BOWER-BARFF PROCESS.

BY A. S. BOWER, C. E.

Any process which has for its object the preservation of iron and steel from rust, and which will make these metals more applicable than they now are to the requirements of mankind, will be sure to meet with attention from members of this Association, and from all those who are either engaged in the extraction of the ore, its reduction to metal, or the subsequent application of the metal itself.

It is, perhaps, not too much to say that with iron and steel rendered secure against corrosion and decay, they will be used to an indefinitely greater extent than they now are. The whole realm of science has, therefore, been explored in the attempt to discover some method by which the formed article may be preserved, leaving its strength undiminished by the destructive action of rust. Paints, oils, varnishes, glazes, enamels, galvanizing, electro-depositing, and what is called "inoxidizing" are among the many systems now in vogue to effect the preservation of iron and steel from the corrosive action of air and water. The object of this paper is to show what may be done in protecting iron and steel from rust by forming upon their surface a film of magnetic oxide by an inexpensive process. It is no new thing to be told that magnetic oxide of iron is unaffected by exposure to the atmosphere or to salt water for any length of time. The black sand of Taranaki, in New Zealand, is a sufficiently good example of this. Doctor PERCY has pointed out that the reason why Russian sheet iron is less effected by exposure than ordinary sheet iron is because of a coating of magnetic oxide; but this was not known until Doctor PERCY discovered it. That such a coating is produced is quite certain, but it is only an accident of manufacture. To Professor BARFF is due the credit of being the first to deliberately undertake to coat iron and steel with magnetic oxide produced designedly for the purpose of protecting their surfaces from rust. Some 16 or 17 years ago my father was making a series of experiments in the production of heating gases, one set of them being the decomposition of water by passing superheated steam through masses of red-hot iron. He noticed that the iron became less and less active until it ceased to decompose at all, when, on examining it, he saw that it was coated with a kind of enamel. It at once occurred to him, on seeing this, that the process in question might be used to obtain such a coating, but he found, after a few days' exposure of the iron to the atmosphere, that the coating shelled off, and he pursued the matter no further. The iron employed in this case was rusty, but if it had been new my father would, in all human probability, have been the accidental author of the process which Professor BARFF discovered ten years afterward. I only mention this to show how advisable it is to investigate the causes of unexpected effects. Professor BARFF's process consists in subjecting iron or steel articles to the action of superheated

steam, and when they are at a temperature sufficiently high three equivalents of iron combine with four of oxygen, forming one equivalent of magnetic oxide, and setting eight of hydrogen free, or symbolically $(1) \text{Fe}_3 + 4 (\text{H}_2 \text{O}) = \text{Fe}_3 \text{O}_4 + 8 \text{H}$.

Upon reading a description of the BARFF process in the London *Times*, it occurred to my father that what the Professor could effect with steam he might also effect with air, and several experiments were made to this end, which, however, were very varied in character, as also were they in the results obtained. The first was made with cast iron by placing the articles to be treated in a cast iron retort, heated externally, and then passing superheated air over them. and it was successful, while nearly all others afterward were quite the reverse, as sesquioxide was copiously produced as well as the magnetic. Another experiment was made by placing a bar of polished cast iron in the main duct of superheated air to a blast furnace, and this, though covered with a red sesquioxide powder and easily brushed off, had a thin but very firm and tenacious coating of magnetic oxide in contact with the iron. This bar has been exposed to the weather ever since, or over four years, without the slightest appearance of rust. Ultimately, when thinking over the fact that air is oxygen and nitrogen in mechanical combination only, I came to the conclusion that, to form the lower or magnetic oxide, the quantity of free oxygen, and so of the air employed, must bear some proportion to the surface of the articles exposed to its action, more especially when a comparatively low heat is employed. This is so, and it has been proved that the quantity of air passed through the retort during most of the unsuccessful experiments was 300 or 400 times more than was actually necessary. The reasons also why the first experiment was successful were that a great number of articles were in the muffle, that a very high heat was employed, and that the retort had been previously used for coal-gas making, and had a deposit of carbon in it, which to a great extent neutralized the effect of the large excess of air.

All the unsuccessfully treated articles were red with sesquioxide outside ; but there was, nevertheless, a coating of magnetic oxide in close proximity with the iron, due to the reducing influence of the metal in contact with the sesquioxide at an elevated temperature. The general appearance however of iron so treated was disagreeable, to say the least of it. The mode of action I then adopted was to admit a few cubic feet of air into the retort at the commencement of every half hour, and then to leave the iron and air to their own devices, the retort, of course, being tightly closed. During each half hour a coating of magnetic oxide was formed, and the operation was repeated as often as was considered necessary. Effective as this was for cast iron, the cost of producing the coating was as great as by the BARFF process, for both of them required that the chamber should be heated externally, and this, with large furnaces, is very expensive. Another plan that I adopted was to first find out approximately the extent of the surface of the goods to be treated, by first dipping them all into a tank of water of known area, lifting them out and noticing the amount of water taken out of the tank by the wetted surface, and regulating accordingly a slow, continuous air supply by meter, of course keeping the temperature of the muffle as nearly constant as possible. This, too, was successful ; but the same objections applied to that mode of procedure as to the other.

There was commenced a series of experiments with carbonic acid chemically produced by the decomposition of chalk, the idea being that three equivalents of iron would unite with four of carbonic acid, forming one equivalent of magnetic oxide and four of carbonic oxide, if the heat were sufficiently high. This reaction is expressed symbolically thus: (2) $3 \text{ Fe} + 4 (\text{CO}_2) = \text{Fe}_2 \text{O}_4 + 4 (\text{CO})$. This is the simplest action that could take place, but it was evident from the results that something quite different was obtained, inasmuch as the coating was very light in color, pleasing to the eye, but easily removed, and in that sense entirely different from the articles you see before you. This coating, from effects exactly similar and designedly produced by a studied manipulation in the furnaces in successful operation in England, France and here, proves pretty conclusively that carbonic acid, practically pure, produces upon iron, at an elevated temperature, a film which is, in composition, a mixture of FeO and $\text{Fe}_3 \text{O}_4$, or, at all events, it is nearer the metallic state than is magnetic oxide. But even supposing that the results obtained by the carbonic acid had been successful as then carried out, the objections referred to concerning the air process would still exist, as external heat and a closed iron muffle would always be necessary. I therefore proposed to use a fuel-gas producer, similar in principle to the SIEMENS generator, but altered practically to suit other requirements, to burn the combustible gasses thus produced with a slight excess of air over and above that actually required for perfect combustion, and to heat and oxidise the iron articles, placed in a suitable brick chamber, by these products of combustion. I also arranged a continuous regenerator of fire-clay tubes underneath the furnace, so that the products of combustion leaving the oxidizing chamber passed outside the tubes, imparting a portion of the waste heat to them, which was taken up by the ingoing cold air passing through their interior on its way to the combustion chamber. I had hoped in this way to be able to so regulate the excess of air over that required for complete combustion as to be able to produce magnetic oxide directly, instead of the lower and useless oxide or combination of oxides produced by carbonic acids alone. I obtained some beautiful results and some again were unaccountably bad, and I soon found it was as difficult to regulate the precise amount of oxidation as it first was in the BESSEMER process, and I was fortunate enough to hit upon an almost parallel remedy—that is to say, I increased the quantity of free oxygen mixed with the products of combustion, and oxidized the iron articles to excess during a fixed period of generally forty minutes, when magnetic oxide was formed close to the iron and sesquioxide over all. Then for twenty minutes I closed the air inlet entirely, leaving the gas-valve open, and so reduced the outside coating of sesquioxide to magnetic oxide by the reducing action of the combustible gases alone.

The excess of oxygen in the first instance produces $\text{Fe}_2 \text{O}_3$, or sesquioxide of iron, and the under surface of this, being in contact with metallic iron, undergoes reduction to magnetic oxide in the following manner: Four equivalents of sesquioxide unite with one of metallic iron, forming three equivalents of magnetic oxide, or, symbolically, (3) $4 (\text{Fe}_2 \text{O}_3) + \text{Fe} = 3 \text{Fe}_3 \text{O}_4$.

When deoxidizing by combustible gases, consisting mainly of carbonic oxide, three equivalents of sesquioxide unite with one of carbonic oxide and form two equivalents of magnetic oxide and one of carbonic acid, and, sym-

bolically (4) $3 (\text{Fe}_2 \text{O}_3) + \text{CO} = 2 (\text{Fe}_3 \text{O}_4 + \text{CO}_2)$. Another method of reduction is by carbon itself, when the formula stands thus: (5) $3 (\text{Fe}_2 \text{O}_3 + \text{C} = 2 (\text{Fe}_3 \text{O}_4) + \text{Co}$.

Formula (4) is also the reaction when rusty iron is reduced by producer gases, and which consist largely of carbonic oxide, and by the specimens exhibited it will be seen that articles completely pitted with rust may have their surfaces rendered rustless. In this case the periods of oxidizing and deoxidizing are reversed—that is to say, the latter occupies forty and the former twenty minutes. No oxidizing is theoretically necessary, but practically a certain amount is requisite to keep up the heat in the chamber, which, of course, could not be done unless combustion took place some time or other. I only mention the reduction by carbon as exemplified by formula No. 5, because, while experimenting with a furnace, I was asked by the proprietors of a valuable red-oxide deposit, which was found in so finely divided a state as to be capable of being used at once as a paint, whether I could reduce it to a magnetic oxide. I tried to do so by carbonic oxide, but I found that only the surface of it was affected, and that even this, when taken out of the furnace, speedily returned to its original red color by the combined actions of the hot unconverted material underneath and the air above. It will be found from formula (5) that $2\frac{1}{2}$ pounds of carbon are required to reduce 100 pounds of red oxide. This I mixed intimately, in the shape of powder, with the red oxide, brought the mixture to a red heat, and the result was black magnetic oxide. Not only this, but by adding more carbon I could make the color lighter and lighter until it was almost identical with the coating produced in my previous experiments with carbonic acid, and by reducing the quantity of carbon below $2\frac{1}{2}$ per cent. various shades of purple were obtained, the red appearing more and more prominent as the quantity of carbon was diminished. It will be as well, before I make any comparison between Professor BARFF's process and those patented by my father and myself, to state that the whole of the Professor's patents, wherever existing, have been purchased by my father, so that in this case at least I hope you will not say that "comparisons are odious." Professor BARFF's process is better than ours for wrought iron, and perhaps for polished work of all kinds, as iron commences to decompose steam at a very low temperature; in fact, much below visible redness. Only the other day, at the annual meeting of the Association of American Stove Manufacturers, held in New York, I was asked whether stove patterns might not be made of cast iron, polished and then oxidized? Here is one among many instances where the steam process is almost invaluable. For ordinary cast iron, and especially that quality which contains much carbon, the BARFF process is much too slow in its action, and some specimens that I have treated in England have taken as much as thirty-six hours to coat effectually, which could readily have been finished off in five hours by the BOWER process.

The main distinction between the two is that the BOWER is much more energetic in its action than the BARFF process. The carbon in cast iron impedes oxidation, and so, while cast is far more readily treated in the BOWER furnace, wrought iron is apt to scale unless it is rusted beforehand. The rust then eats into the metallic surface under the influence of heat, and forms a tenacious combination with it. The objection to the use of a closed muffle

externally heated in the BARFF process has been almost entirely overcome by simply putting wrought iron into a BOWER furnace, previously well heated then shutting off both the gas and air supplies, and admitting steam into the regenerator tubes. The steam thus passes through the red-hot tubes, then through the combination chamber and its contingent passages, already highly heated, over the articles in the oxidizing chamber, heating and oxidizing them, and thence over the outside of the regenerator tubes, depositing a great portion of its heat there before passing to the chimney, and which is again picked up by the ingoing fresh, cool steam. In this way the heat in the chamber is highest shortly after the commencement of the operation, and gets gradually lower during the time of exposure, which varies, according to the class of goods, from five to ten hours. At the close of the operation, just before the articles are taken out, everything is moderately cool, and this for steam is the perfection of action, as stated by Professor BARFF himself. Steel, I consider, can be equally well treated by both processes, and, indeed, it is natural to expect this, steel being, so far as the quantity of carbon it contains is concerned, between cast and wrought iron. Polished steel, however, is better treated in a low-temperature BARFF furnace.

With regard to the quality of fuel burned in the gas producers, a non-cooking gas coal is the best, and Virginian splint has suited very well in this country, and of this about 1 ton every three days is required for a furnace with an oxidizing chamber 13 feet long, 4 feet 3 inches wide, and 4 feet 3 inches high. When a gas coal is employed, it should be fed through the charging hoppers just before each deoxidizing operation, when a smoky flame is of great advantage. I have, however, discovered that anthracite can be used as well as a gas coal, by simply allowing petroleum to drop at the rate of 1 gallon per hour upon the red-hot surface of the coal in one of the gas producers. This method has been exclusively used in the coating of the articles exhibited in this room at the works of Messrs. POULSON & EGER, architectural engineers, at North Eleventh and Third streets, Brooklyn, E. D., N. Y., to whom I am much indebted, not only for these beautiful castings, but for the constant courtesy and energy they have always exhibited during the erection of their furnaces. At present they have two erected, one a BOWER furnace of the size before mentioned, and the other a small BARFF furnace for the treatment of very delicate or polished articles. These magnetic oxide processes not only protect from rust, but the coating is of such a beautiful color as to render articles ready for the market as soon as they are out of the furnace and cooled. One remarkable feature of them is that there is no more cost (except in the labor of handling them) in treating 2,240 articles, each weighing a pound, than there is in coating a cube of metal weighing a ton; and so penetrating is the process that, no matter how intricate the pattern may be, every crevice—which it would be almost impossible to get at with a paint brush—is as effectively coated as the plainest surfaces, as will be observed by examining the specimens exhibited in this room. For art purposes the French gray color, with shades approaching to black, might not always be suitable; but if it should be necessary to use paint on the iron so coated, there is the absolute certainty that it will remain on in the same way as it does on wood or stone, and thus iron may be used for constructive work in a thousand directions in which it has not up to the

present time been possible, on account of its liability to rust, no matter what the coating used to protect it has been.

I can give an instructive instance of this. A company in Paris had expended a very large sum over DODE's inoxidizing process, which process consists in the depositing of a layer of borate of lead on iron or steel, and then gilding, platenizing or bronzing them, and certainly the articles so treated were exceedingly beautiful to look at; but the iron ultimately rebelled and threw off the coating, so that the shareholders were in a fair way of losing all their capital, when it was suggested to the directors that if their compositions could be deposited direct upon magnetic oxide, they would conquer the difficulty. They then applied to my father for specimens of coated iron to experiment upon, and they were so satisfied with the result that the company purchased all our European patents except England, and are carrying on the combined processes on a large scale. They have, besides their furnaces for the DODE process, four large BOWER ones, two being 36 feet long by about 6 feet 6 inches wide and 6 feet high, and a BOWER BARFF furnace, also of large size. Others, however, are in course of erection.

Engineers and manufacturers appear far more ready to apply the processes here and on the Continent of Europe than up to the present time they have been in England; but perhaps the reason has been that, so far as Professor BARFF's process is concerned, it has only just been shown how large masses can be dealt with—namely, by the use of the BOWER furnace—and I can show that for the treatment of underground pipes, wrought iron sleepers, roofing and the like, the process can be readily applied, and at a cost much less than that of galvanizing, and it will at the same time be infinitely more durable; while for ornamental cast and wrought iron it is scarcely possible to imagine anything more artistic in color than some of the articles after they have been treated. For ordinary hollow-ware for kitchen use, whether of cast or wrought iron, this process is admirably adapted, and though I have been told that the gray or black color will probably be objectionable, yet I imagine, if it can be shown, as we can do, that the magnetic oxide is more durable, more easily cleaned and much cheaper than even the common tinted article, a market will soon be created. Anyhow, the new combined processes are so far developed and they have been so thoroughly examined by scientific and practical men both here and in Europe (whose testimony to the value and efficacy of them is voluminous) that they have passed from the region of theoretical investigation into that of practical application, and means have been taken for establishing works in different centers in Europe, as will also be done here, for the purpose of coating iron and steel as a trade operation. One firm alone in Scotland, Messrs. WALTER MACFARLANE & Co., have adopted the process, their output of ornamental castings per day exceeding 100 tons! It is intended to apply the process to cast iron gas and water pipes, and as the former have comparatively no pressure to bear they may be made much lighter than they now are if rendered incorrodible; while for water it will be a great advantage to have both the main and service pipes rendered safe from rust, which not only discolours the water, but forms the nucleus of very troublesome deposits. There is no reason now why wrought iron or mild steel pipes should not be used for the same purposes, especially for the interior towns of distant countries, where the first cost of the pipes is but small as compared with the cost of carriage.

My father has himself used gas and water pipes where the cost on arrival at their destination has been five times greater than their first cost in England. If, then, light wrought iron or steel pipes could be used, not weighing one-third of those made of cast iron, and rendered practically indestructible, what an enormous saving will be effected! Again, in the case of railway sleepers in iron and steel, which are now almost wholly used in Germany, the process is likely to prove of much advantage, so at least I am told by engineers, both in Belgium and in Germany; and if there, why not here? For fountains, railings and all architectural work the process is invaluable, and iron may now be used in many instances instead of bronze. It will naturally be asked, what is the cost of the process? I cannot do better than answer the question by quoting from the report of Professor FLAMACHE, the engineer-in-chief of the State railways in Belgium, who was sent over specially to England to report on the process by the Public Works department of that country. His estimate of cost, after a very careful examination and testing of the process, was $7\frac{1}{2}$ francs per 1,000 kg., or nearly \$2 per ton, at, of course, the Belgian rate of expenses. He also gives the cost of coating a certain extent of surface, but this I consider to be completely valueless, as, for example, I have had a furnace full of 56-pound weights, and another time I have had it full of gas-governor tops, the surface in the latter case being perhaps one hundred times more in extent than in the former, while the actual cost of oxidizing would be the same in both cases. He also says that this cost may be reduced, as instead of one workman attending to one furnace, he can attend to three or four; also by a better system of taking the articles out than existed in the experimental furnace that he saw. Sir JOSEPH WHITWORTH, feeling much interest in Professor BARFF's process, sent to him some steel to be oxidized, so that he might ascertain whether it did or did not lose in strength by the operation, and the result of Sir JOSEPH's testing was that there had been no alteration whatever. Theoretically, one would rather expect that iron and steel would be somewhat toughened, as the tendency of the process is to anneal, and would, no doubt, if continued long enough, render some classes of cast iron malleable. A very thin article, if excessively coated, might probably be weakened, due to the fact that the coat of magnetic oxide would form an appreciable percentage of the bulk of the article; but this, of course, is a very extreme case, and one which is not likely ever to occur in practice.

The development of these processes has been a long and tedious business, and one requiring much faith and patience in the midst of most disheartening failures for months together; but to gentlemen connected with the iron and steel industries, and who know well that results are only obtained by patient and well-directed toil, I need not dwell on this, as almost every man who has had to reduce theory to practice has had abundant experience of the same kind.

The following extracts are taken from an article which appeared in the *Revue Universelle*, published in Belgium.

After describing the furnaces and chemistry of the process the writer says :

The rustless articles withstand the effects of heat, while coverings of paint, galvanizing, tin and enamel suffer very much under its action. A piece of rustless iron can be heated to redness, and then plunged into cold water without the least scaling or other change, so slight is the difference between the coefficients of expansion of the magnetic oxide and the metal.

Rustless iron is not affected by fresh water holding air in solution, nor by brines or alkaline solutions or sulphuretted gases, and it withstands the action of salts in general, especially sulphate of copper.

Coated articles may therefore be exposed to sea water or to the most varied atmospheric conditions. Cast iron receivers used for six months as urinals remained perfectly free from corrosion, while similar receptacles not protected by the oxide were strongly attacked.

VAN AUBEL, engineer of the Maestricht Royal Paper Factory, treated several articles, and then exposed them to the fumes of the laboratory without any deterioration.

FLAMACHE, engineer of the Belgian State Railways, makes the following statements in a report on the BOWER process :

1. Hydrochloric acid deluted to $\frac{1}{10}$ converts the magnetic oxide into sesquioxide which it dissolves, and into hydrated sesquioxide which scales off the surface, exposing the metal to the direct action of the acid.

2. Nitric acid diluted to $\frac{1}{10}$ does not act on rustless iron.

3. A solution of caustic soda has no effect on the coating. If there is a crack in the coating, the exposed metal will rust as usual, but the rust will remain localized.

Though the adhesion of the BOWER-BARRF coating is considerable it is not sufficient to permit of working and fitting iron in the same way as material that has not been treated. Rustless nails can be driven into wood and then withdrawn without injury to the coating. Coatings can be drilled without injuring the coating on the rim of the holes.

FLAMACHE claims to have obtained the following results :

1. The rustless treatment does not alter the strength of the iron.
2. Under tensile or compressive strains the oxide adheres firmly to the iron until the limit of elasticity of the metal has been reached.
3. The oxide is chipped off the metal by a blow of the hammer ; in riveting the coating to a distance of one centimetre around the rivet head scales off ; and in shearing the coating scales along the edge of the metal.

According to these tests iron can be protected from rust when the articles are not to be submitted to subsequent mechanical treatment.

The magnetic coating can be reduced in thickness to a mere film, which will protect fine castings and polished ware from any but very energetic rusting action, producing at the same time a very artistic effect.

The first articles treated at the Hecla Works were suspended from the ceiling of the plating room, where they have been exposed above the vats to warm steam and acid fumes since the 20th of January last. They are absolutely unattacked, while plated and galvanized articles hung up at the same time were speedily red with rust. Articles hung in the exhaust steam in the foundry yards were also unaffected.

The following extracts from English and American journals are of value, because they all uniformly endorse the value of the process.

NOTICES BY THE PRESS.

EXTRACT FROM "THE LONDON TIMES," 6th MARCH, 1877.

Many attempts have been made to protect iron surfaces by the application of some kind of paint or varnish ; and these attempts have, of course, been to some partial extent successful. Such coatings, however, have no real adhesion to the metal on which they are placed, and are liable to scale off or to perish in a variety of ways. Even when the coating is generally sound, the smallest flaw in its continuity will give entrance to the enemy ; for the rust from the exposed spot will spread laterally under the coating, and may be all the more dangerous and destructive from being partially concealed from view.

The oxidation does not affect the appearance of the surface in any other way than by turning it black. A rough forging retains its roughness, and a turned and polished surface retains its smoothness. If there should be any flaw in the coating, or if the black oxide is designedly removed from part of the surface, the common oxidation will occur where the iron is thus left unprotected ; but such oxidation is strictly limited to the unprotected portion, and has not the smallest tendency either to spread laterally or to detach this from the subjacent parts.

EXTRACT FROM "THE LONDON TIMES," 28th JUNE, 1880.

With respect to the protection afforded to the metal by this process, we may observe that the oxide thus formed has been tested very critically, and is found to withstand all ordinary atmospheric conditions perfectly. It appears to be thoroughly incorporated with the metal, as indeed it must be, for it is the union of the iron with oxygen which forms the coating.

EXTRACT FROM "THE ENGINEER," LONDON, 7TH MAY, 1880.

To say that the black oxide is indestructible under the ordinary influences of the weather is to state a truth known for many years to chemists. The articles which we have seen have a coating of this oxide, not existing there as a scale, but apparently incorporated with their substance. It would be but a waste of time to point out the enormous advantage that will accrue from rendering iron castings as incorrodible for all practical purposes as gold.

The special feature of the process is its simplicity of application. For a very moderate sum cast iron can be rendered indestructible with certainty and despatch.

FROM "THE BUILDER," LONDON, 8TH JUNE, 1878.

The coating has been subjected to the severest tests, and has invariably resisted all attacks of both air and moisture, and there is every reason to believe that this process will, when completely developed, entirely supplant every other method of protecting iron from rust.

EXTRACT FROM "THE LANCET," LONDON, 16TH NOVEMBER, 1878.

Its application to sanitary purposes is obvious ; it will be a great boon to have water-closet pans, soil pipes, traps and urinals which do not corrode. We saw a urinal which had been in use for many weeks, and upon which, curiously enough, the urine had not even left a stain ; the latter fact is very strange, and not very easy of explanation. For water pipes the black iron will be invaluable, and also for water cisterns. For cooking it is quite equal to copper, and does not lead to the occasional danger of copper poisoning, which arises when copper utensils are employed. For making pickles we believe it is necessary, or at least it is the custom in large factories, to use vessels of platinum, the cost of which is enormous.

EXTRACT FROM "THE PLUMBER AND DECORATOR AND JOURNAL OF GAS AND SANITARY ENGINEERING," APRIL, 1881.

Rather more than five years ago Professor BARFF made public his process for protecting iron surfaces from rust by coating them with magnetic oxide. Shortly afterward, Mr. GEORGE BOWER, of St. Neots, the well-known gas and water engineer, revived an old process he had discovered and laid by some fourteen years ago. This process Mr. BOWER patented, and followed up his first patent by some other patents, each an improvement on or rather simplification of its predecessor. Both patentees practically claimed the same results, and yet the processes are practically and legally distinct. The result aimed and arrived at by each patentee is the economical production of a tenacious coating of magnetic oxide on the surface or surfaces of the iron so treated. These results have been obtained independently, but quite recently the rival inventors have joined their forces with the happiest results, both from a prac^t

tical, as well as from an economical and trade point of view. Originally, the iron articles requiring protection were subjected, in a furnace or crucible, to heat of greater or lesser intensity, and while in a heated condition superheated steam in the BARFF process, air and afterward carbonic oxide in the BOWER process. The BARFF process was essentially an oxidized process; the BOWER process is a double one, for in it the iron articles are first oxidized and then deoxidized. The result in the BARFF process is a beautiful coating of dark black magnetic oxide. In the BOWER process the magnetic oxide is delicate steel or French gray.

The union of the new processes among many advantages effects this—the BARFF process was especially adapted for wrought iron and steel, while the BOWER process maintained an easy pre-eminence for cast iron. Now, in the BARFF-BOWER or BOWER-BARFF process, wrought iron, steel and cast iron can be worked with equal permanency and expedition.

There is hardly need for an elaborate account of the *modus operandi* of these patents. They are short ones, and can be readily consulted by those interested. The several improvements and modifications brought about by the union of the patentees almost constitute a new invention.

The special adaptability of the processes to the iron work used in sanitary and plumbing goods, where the surfaces are constantly exposed to the action of water, is self-apparent. Rust is at present the great drawback to the use of iron in water-closet pans and containers, soil pipes, traps, gullies and gratings, as it offers the first resting place for the excreta, which eventually fouls and clogs the parts exposed, and becomes a source of annoyance and disease. It is also patent how specially applicable the BOWER-BARFF processes are for hot water pipes, guttering and rain water pipes—indeed, for every description of iron work that can be affected by rust.

As to the permanence of the protective covering and its unlimited application to all outdoor and indoor iron work of a stationary character there can now be no question. Articles protected by either process have been exposed to every conceivable test, and with the happiest results. So ornamental and artistic is the appearance that we verily believe Mr. RUSKIN's heart would be delighted; but men who have souls above a beautiful black or pure silver gray can paint or gild or enamel their iron work over the protective coating, and rest assured that no insidious rust will by and by break out and injure or mar the beauty of their work. The French, with their love for ornament, have welcomed with open arms Mr. BOWER's invention, and both on its own merits and in combination with a novel and special process for gilding, bronzing and enameling, "BOWERIZED" iron is now being manufactured on a very extensive scale in Paris, and also in Germany.

Such happy inventions occur but seldom, and the inventors are to be congratulated on having struck such a golden mine. The cost is a mere trifle in excess of that of unprotected iron. Unlike galvanizing and other old-fashioned protective processes, no coating is added to the articles. Their own existing surfaces are so treated as to become, without any addition, their own protectors. A rust that will not rust is produced, and this not only permanently increases the usefulness of the article, but adds in an equally enduring manner to its beauty.

FROM "THE HARDWARE TRADE JOURNAL."

Enormous quantities of iron tubes are being treated by the new process with uniform success; and it has been found very suitable for the treatment of stable and harness room fittings in iron, thus dispensing with the more costly process of enameling the surfaces hitherto pursued.

FROM "THE EVENING STANDARD," LONDON, 7TH MAY, 1881.

It may not be quite correct to say, as Mr. GEORGE BOWER, of St. Neots, said yesterday in a paper read before the Iron and Steel Institute, that "if iron and steel were rendered secure against corrosion and decay, they would be used to an infinitely greater extent than they are now," but it is beyond question that they would be used with infinitely greater satisfaction. In the use of iron out of doors, rust is something more than a mere fly in the pot of ointment, and is often prohibitive of the employment of wrought iron altogether. Anti-corrosive paints of more or less efficacy and ugliness have been tried by the hundred, but have proved at best only palliatives of the evil. Of the galvanizing process one must speak with respect, but it is far from being generally applicable. And yet for some time past it has been known that, by a process at once simple and inexpensive, iron and steel might be made their own protectors. Any iron article treated by this process puts on every surface a thin coating of magnetic oxide, absolutely impervious to rust. Over this paint can be used, if it is needed, for decoration, but it is not required as a protection. This fact, we say, has long been known; but the public has not grasped the fact, and the good people who supply the public with ironmongery do not seem to care that it should. Who is interested that the area railings, the gratings, the gutter pipes, the fender and fire irons, locks and bolts, and the like, which the British householder buys and pays for, should not waste with rust? Certainly not the ironmonger, wholesale or retail, who supplies them, or to whose men they furnish endless small jobs for repairs. Mr. BOWER tells us that even engineers and manufacturers, who employ iron articles on an enormous scale compared with the general public, are far more ready to apply the process on the Continent than here. And yet we seem to see a fortune to be made by the man who should properly introduce, say, only household articles thus protected to the notice of Londoners alone. There are many invitations to make fortunes being put forward just now. This would prove a sounder speculation than most.

FROM "IRON," LONDON, APRIL 7TH, 1882.

The preservation of the surfaces of iron and steel from rust is a matter of such leading importance, both constructively and artistically, that we gladly embrace the opportunity of placing before our readers a few particulars respecting the progress and development of the two well known processes for effecting this object by oxidation. These processes are respectively those of Professor BARFF and of Messrs. GEORGE and A. S. BOWER, and the present

opportunity of reporting progress has been afforded to us by a recent visit to Messrs. BOWER's works at St. Neots, where we saw the combined processes in operation. From the various notices which have appeared in our columns, it will be remembered that the BARFF process is for subjecting iron and steel at a red heat to the action of superheated steam, when the latter is decomposed ; the oxygen combining with the iron and forming magnetic oxide, the only oxide of iron which is not affected by atmospheric conditions. The BOWER processes comprise the use of ordinary air, and also of carbonic acid gas, produced from the combustion of carbonic oxide inside the chamber in which the articles under treatment are placed. The BARFF was admittedly better than the BOWER process for wrought iron, but it was costly, while the BOWER process was better for cast iron and steel, and much cheaper. The BARFF process is a direct one, the magnetic oxide being formed as a direct result of the decomposition of water, while the BOWER process is an intermittent one, the magnetic oxide being formed by a series of oxidizing and deoxidizing operations. The former hitherto required the chamber or muffle to be heated by an external application of heat, and the steam superheated by an independent furnace, while the latter is effected by an internal application of gaseous fuel with more or less of air to effect either the oxidizing or deoxidizing operations. The happy combination of the two systems has enabled the Messrs. BOWER to devise a furnace which embraces all the good points of both, as in it it are performed all the various operations of producing carbonic oxide, generating and superheating steam, heating the chamber by either an outside or an inside application of gaseous fuel, and treating therein either wrought or cast iron at pleasure ; the cost, moreover, being very materially reduced. So far as the oxidizing of iron and steel goes, it would seem that the process as now practiced cannot well be made more simple or less costly ; and there appears to be no reason why iron and steel, in every variety of form and size, should not now be used with confidence for purposes to which, hitherto, they have been applied with doubt and hesitation. Take, for example, the underground railway, and let any one examine the girders, columns, and other ironwork, which are visible, and note their condition, and he will see the necessity of such structural work being properly and permanently protected from corrosion. Let any one, too, examine the condition of the underground pipes, both of cast and wrought iron, by which our gas and water are supplied, and he will come to the conclusion that an extra pound or two per ton expended on their preservation at starting would be money well spent.

Not only, however, is there a wide field for the application of the process to useful purposes connected with construction, but for domestic and art work, where the field appears to be illimitable. The ordinary pots and pans of a kitchen, grates and fenders, and other ironmongery of houses can all be oxidized at a cost almost as small as that of painting, while it has recently been discovered that the process of enameling is much expedited and reduced in cost by first oxidizing the article. For ornamental purposes gold and other metals can be deposited direct on the oxide by a very simple process, with the certainty that they will remain there and not be thrown off by corrosion underneath. The same may also be said of paint, where it is necessary to use it for decorative purposes. When once on the coated iron

there it remains, and will be no more affected than it is on wood or stone. In this connection it is interesting to note that Mr. BOWER has recently patented a very curious and interesting discovery which will still further enable iron to be used in substitution of the more expensive metals. The patent consists of a metallic brush, the wires of which are formed of the metal it is desired to deposit on the iron. On applying the brush briskly to the surface of any article which has been first coated with magnetic oxide, some of the metal is deposited, producing a very beautiful effect; all the prominent parts having the greatest deposit, which gradually shades off the color of the magnetic oxide, which is a pretty French gray; so that in this way gold, silver, nickel, copper, brass, bronze or other metallic alloys may be deposited by mere attrition. If the article is slightly heated after the operation the metal appears to be permanently fixed. Mr. BOWER considers it to be a purely mechanical operation, and to be due to the fact that magnetic oxide not being a metal, and presenting a somewhat gritty and porous surface, the metal of which the wire is composed is taken off by friction, and the pores filled up, as when this has been once done no other metal can be deposited upon it by the same means. The brushes may be actuated by manual or mechanical power, the cost being but little more than the labor, as the metal is deposited in a very attenuated form. Here then is another wide field for the use of the BOWER-BARFF process for art purposes; indeed, it would seem that the limit is indefinable, and that iron will maintain its high position or all purposes, seeing that it can now be preserved from corrosion and used with safety for constructive purposes, while for art work the process will enable iron and steel to be used in place of the more expensive metals. We understand that the various English patents relating to the BOWER and BARFF protecting processes have now become the property of an English company. The same may be said of the Continental patents, which have been transferred to a French company having its headquarters in Paris. We have recently heard of an order being given to the French company for coating 12,000 stoves, and the process is being taken up with great spirit in Germany. It would seem, therefore, that those interested in the production and application of iron and steel are welcoming a process which will not only confer important advantages upon themselves, but also upon those who are still more widely interested—the public at large.

FROM "THE METAL WORKER," NEW YORK, 22D JULY, 1882.

"The company controlling the BOWER-BARFF process in France have just concluded contracts to treat and embellish 12,000 stoves."

This announcement, which comes to us by letter, suggests some thoughts which may not be without interest for our readers. As long ago as the Rochester meeting of the National Association of Stove Manufacturers, the editor of the *Metal Worker* called the attention of the trade to the value of the BOWER-BARFF process for the protection of iron surfaces, and suggested it as an excellent treatment for stove plates. The idea then suggested has now been applied abroad, and, if adopted here, it will be after foreign manufacturers of stoves have utilized it for its full value.

Primarily the BARFF and BOWER processes were each worked out by different inventors for the purpose of attaining the same object, viz.: the coating of iron with a magnetic oxide which would render it impervious to the action, either singly or combined, of air, gas and water—either fresh, sewage or marine—and to a great extent that of chemicals. Professor BARFF was the first to accomplish this result with wrought iron by the practical application of his now well known discovery that a current of superheated steam injected over the surface of the iron at a high temperature, would produce a hard coating of magnetic oxide. This process has been in successful operation now for some years past, but Mr. BOWER, who had been experimenting in a similar direction for many years, stumbled almost accidentally upon the germs of this discovery, and the success of the BARFF process stimulated the BOWERS, father and son, to make improvements upon the original, and to accomplish, by means of atmospheric air and the products of combustion, that which Professor BARFF had attained by means of superheated steam, and in this they have been quite successful. The ultimate result is that the processes are now perfect in their results, the patent rights of Professor BARFF having been purchased and incorporated in the combined working of the BARFF-BOWER patents. The patents and processes in use include the following operations:

1. Professor BARFF's original process, which is found to be specially adaptable for wrought iron.

2. The BOWER process for coating iron (more particularly cast iron and steel) with magnetic oxide, by means of two operations: 1st. The admission of atmospheric air to the furnace which oxidizes the metal. 2d. The admixture of the products of the combustion of fuel, and at times, if required, of gas from oil, to deoxidize, or rather convert the sesquioxide of iron (Fe_2O_3) into the magnetic oxide Fe_3O_4 . This oxide, when it is met with in its natural state, is the loadstone of commerce. The first part of the process produces rust or its equivalent the second the transformation of this rust into a coating of impervious magnetic oxide. This is the general description of the chemical changes which the surface of iron undergoes, but the exact composition of magnetic iron has not been decided. Even by chemical experts it is assumed rather than determined that the composition is Fe_3O_4 , but doubt exists as to the accuracy of these figures. The working of the oxidizing and deoxidizing process, as we saw it, is exceedingly simple. The goods, consisting of weights, half hundred weights, stove castings, ornamental and fine art castings, were placed in an oven capable of holding about a ton, though of course there is no limit to the size of the castings which can be operated upon except that of the furnace. Air at a high temperature is then admitted to the castings, and after a time carbonic oxide, evolved either from the combustion of fuel or from a gas producer, somewhat on the SIEMENS principle, in combination with the furnace. The admission of either atmospheric air or carbonic acid is, of course, under perfect control, and the best results are obtained by admitting the air and gas alternatively at regular intervals during the process, which usually occupies from eight to ten hours, and the result can be always relied upon to a certainty, for notwithstanding the enormous amount of care, skill and scientific experimenting which was involved in perfecting the process and making it a reliable mechanical operation, it can be carried on now by a comparatively unskilled workman, as the only extra work which the furnace

attendant has to do is to regulate the supply of gas and air at intervals, and this is done merely by turning a handle. Hence the BOWER-BARFF process has almost attained the perfection of scientific mechanism, as the results are certain and the action simple.

One of the most valuable features of Mr. BOWER's system is that the rust on iron surfaces can be converted into magnetic oxide. Any iron or steel, therefore, that has become damaged or unsaleable by exposure—such as, for instance, tubes, pipes, gas standards, brackets, pillars, rails, and ornamental work—can be restored permanently to their original beauty, no matter how thick the incrustation of rust may have been, since the sesqui-oxide of iron is converted into the magnetic, and hence the goods are eventually improved, instead of being deteriorated, by the rust. The value of this part of the process will be appreciated by those who have to keep iron stocks of any kind. The cost of the BOWER-BARFF system does not involve a serious item of expense. The furnace we saw would contain a ton of miscellaneous articles, and it is immaterial whether the ton consists of 2,240 articles weighing one pound each, or that it be in one solid block, the operation is equally effective in either case, requiring only five or six hundred weight of small coal and the attendance of one laborer for one day of ten hours. In foundries where there are blast furnaces, the cost could be reduced considerably, since the hot air blast could be used for oxidizing, and the furnace gases for deoxidizing. For those who propose to work the BOWER-BARFF, patents continually under license, Mr. BOWER has devised a special form of furnace, which places the gases and atmospheric air under perfect control, and enables the castings in the ovens to be examined during the operation. We need not, however, go into the details of the construction of the BOWER patent furnace.

In delicate castings, architectural and fine iron work, the process gives perfect immunity against rust, since it penetrates the most delicate tracery and affords ample protection, no matter what vicissitudes of climate or marine exposure the goods may be subjected to. For all iron goods, and those countless productions known in Birmingham as "steel toys," the system will be an invaluable preservative, especially as Sir JOSEPH WHITWORTH certifies that that neither steel nor iron lost either in tensile or crushing strain by the operation; in fact, the tendency would be rather to strengthen, on account of the extra annealing process.

When the goods first come out of the furnace they have a beautiful bluish bloom upon them. This changes into a dead black by rubbing with oil, but, if necessary, a silvery French gray tint can be imparted to the goods, so that for ornamental work one or two shades of color can be provided. One peculiarity that these oxidized castings have is that, if they are brushed over with a metal wire brush—say of brass, copper, or fine iron—they become coated with a thin deposit of the respective metals, and made to simulate oxidized silver, brass, or copper. This has been patented, and it opens out quite a new field for the ornamentation of iron after it is coated with magnetic oxide. The surface also takes electro depositions of metal without difficulty, and nickel deposited on the film of magnetic oxide would never be impaired by any tendency on the part of the iron to rust under it. We really cannot see why the BOWER-BARFF process is not of great value to stove makers. Prof. GEORGE W.

MAYNARD, No. 24 Cliff Street, New York, has secured control of the BOWER-BARFF patents for this country, and is about to organize a company to apply them practically.

FROM "THE NEW YORK TIMES," JULY 15, 1882.

The great objection to the use of iron for architectural purposes, as has been repeatedly referred to in the columns of THE TIMES, is the fact that it rusts easily and is weakened materially by the rusting. To obviate this difficulty, galvanizing and the use of paints of various kinds are processes that have been tried, but absolute success in overcoming the process of natural oxidation resultant upon exposure to the air and weather has not been secured. Paint, or any other material that does not become a portion of the iron itself, permits oxidation underneath the surface or scale. An objection to iron thus treated has also been the color and the expense of frequent replenishing of the coats of paint in order to preserve the iron itself and its appearance. Up to the present time no process has been discovered or practiced in this country which has been able to overcome the inclination to oxidation or rust. A process has, however, been perfected in England, and is in use in that country, and in France, Germany and Belgium, which has overcome the evil and made iron absolutely rust-proof. And, curiously enough, the system of treatment requires the artificial rusting of the iron before it can be rendered rust-proof. The process is that known as the BOWER-BARFF process. It consists in artificially creating a coating of magnetic oxide of iron on the surface of the iron. Magnetic oxide of iron, as is well known, in its natural state is unaffected by exposure to the atmosphere. That fact led to a long series of experiments by Professor BARFF, of England, which were not wholly successful, save in the treatment of wrought iron, as a uniform coating of the magnetic oxide could not be obtained. His process consisted in the treatment of iron or steel in an externally heated chamber to an atmosphere of superheated steam. Mr. GEORGE BOWER and his son, Mr. A. S. BOWER, simplified this method of treatment by using internally heated chambers or ovens, and using air heated to a high temperature in the place of steam. By a combination of the two processes there resulted the present one, which has been prosecuted in Europe for two years with the most complete success. The iron articles which it is designed to make rustless are placed in a fire-brick chamber. Connected with the chamber is a series of gas producers. The gas, as produced, is led along passages and mixed with air in a highly heated condition, and consumed, the product being carbonic acid. This, and a small quantity of free air, enters the chamber, and are partially deprived of their oxygen by their contact with the heated articles. The result is the production of a coating of magnetic oxide incorporated with the surface of the iron. Over this there is, however, a thin coating of the sesquioxide of iron or rust. This process of oxidation occupies about half an hour. At its conclusion the air is shut off, and carbonic oxide admitted to the chamber, the result being that the coating of rust is converted into a magnetic oxide. The deoxidizing process consumes a quarter of an hour, and the repetition of the processes produces a coating of any desired thickness. The reason why this process is so much superior to any process of galvan-

ization, enameling, or any other plan yet devised, lies in the fact that the coating is not a scale, but is virtually made a portion of the substance treated. A singular fact in connection with the process is that a portion of rusted iron can be thrust into a chamber, subjected to the treatment, and be at once converted into a rustless bit of iron. If a chalk mark be made on a bit of iron subjected to this treatment, or if any of the sand from the foundry clings to the material, it makes no difference in the success of the oxidation, as the process goes on underneath these foreign substances as effectually as though the iron were perfectly clean.

After treatment in this way the iron comes from the chambers of a French gray color, with shades deepening to black. It can then be bronzed, gilded, or silvered, and paint applied will remain on it in the same way that it does on wood or stone without flaking off, as it does from iron that does not have the magnetic oxide coating. The discovery is pronounced by the iron men, engineers and plumbers of the old world as one that will create a complete revolution in the iron business, as iron of all kinds for architectural purposes, iron household utensils, gas, steam and water pipes can be thus treated, and all danger of their failing of their designed purposes by reason of rust can be removed. The process is soon to be introduced into this country, and its adoption here would seem to be almost an absolute certainty, as several large manufacturers in this and other cities have applied to the English patentees for the right to use the process.

EDITORIAL NOTICE OF THE PROCESS IN THE "ENGINEERING AND MINING JOURNAL,"
MARCH 3D, 1883.

Of the importance of the Boston papers (read before the American Institute of Mining Engineers) we need not speak at present. Perhaps the most important, practically, was that presented by Messrs. MAYNARD and BOWER, describing the BOWER-BARFF process for the preservative treatment of cast and wrought-iron surfaces. This cannot be called an entirely new subject, since the process is in wide use in Great Britain and Europe, though it has but just been introduced here. But we do not remember any description of it so full, clear and satisfactory as this paper contains. Of the commercial importance of the subject there cannot be two opinions.

EDITORIAL NOTICE FROM THE "METAL WORKER," OF MARCH 17TH, 1883.

THE BOWER-BARFF PROCESS.—Elsewhere in this issue we give an illustrated description of the plant and process for treating iron by the BOWER-BARFF method, which produces on the surface of the metal a coating of proto-sesquioxide of iron, which is not only so tenacious that it cannot be removed, but is absolutely unchangeable, and cannot be oxidized by the atmosphere or by water. During the past two or three years this process has been greatly improved, but in its essential features it is identically the same as described by the writer of this article in a paper read at the Rochester meeting of the National Association of Stove Manufacturers several years ago, and in which

the process was recommended as meriting the consideration of stove manufacturers. Within a few weeks we have had opportunity to examine a large number of specimens of cast iron and wrought iron treated by the BOWER-BARFF process. The results are extremely satisfactory, and it is now beginning to attract the attention of stove manufacturers to a considerable extent. We are not authorized to say what licenses have already been arranged for, but we think it probable that in another year a considerable number of stoves rendered rustless by this admirable method of surface treatment will be placed on the market. In its application to stoves the BOWER-BARFF process has a marked and obvious utility. The cost of treating a stove by this method is comparatively trifling, and the advantage of having a surface which can be cleaned by wiping with a wet cloth, and which requires no blacking or polishing of any kind to keep it bright and sightly, will be evident to every manufacturer. Cook stoves treated in this way would be very much more convenient articles of kitchen furniture than stoves liable to disfigurement by rust whenever water happens to be spilled on their tops. It is probable, however, that the process will find its principal application, so far as stoves are concerned, in the treatment of the higher grade of heating stoves, which are liable to suffer serious deterioration from rust during the summer months when they are relegated to cellar or attic. The process also has obvious value in its application to all forms of odd castings, and especially to work to be subsequently treated by electro-deposition. Any of the metals now employed in electro-metallurgy can be deposited upon this magnetic oxide with perfect freedom, and as the iron under the coating cannot rust, even a thin film of electro-deposited metal will wear longer and suffer less than would a heavier deposit on a rustable iron surface. But the applications of this method of treating iron are much too wide to be considered in a brief article, and, in conclusion, we can only say that if some of the gentlemen for whom the matter now has a great deal of interest had looked into it when it was first brought to their notice, they would have secured for very little rights and privileges which will now cost them a great deal of money. However, this is a matter in which we have no interest further than that which every man identified with industrial progress may be expected to feel in seeing a valuable process applied in the arts.

EDITORIAL NOTICE FROM "MECHANICS" OF MARCH 10TH, 1883.

Mr. BOWER's paper on the BOWER-BARFF process is one of exceptional interest. In fact, everything relating to the subject of producing a protective coating on iron is of the highest interest at the present time. A good deal has been said upon this subject, and details of these processes have been repeatedly mentioned in scientific papers, yet we think there has not before been so good an exposition of the methods and results as has been given in this paper. The combination of the two inventions has given us a far better, more economical and more widely applicable process than either of them alone. It was an unusually wise course on the part of the inventors to combine their efforts, rather than to expend their energies in useless fighting in the courts.

EXTRACTS FROM LETTERS AND TESTIMONIALS.

FROM T. MAXWELL WITHAM, ESQ.

5 GRAY'S INN SQUARE, LONDON, March 10th, 1879.

The portions of rollers skates treated by your process have given great satisfaction. Before being so treated it occupied one man to keep them free from rust, as the skates are at Ostend, and the rink close to the sea ; but since they have been treated they are quite free from rust. The skate fittings you treated for me personally have also given great satisfaction, but these have not been submitted to the action of the sea air like those at Ostend.

FROM MESSRS. JOHN DEWRANCE & CO., ENGINEERS.

158 GREAT DOVER ST., BOROUGH, March 18th, 1879.

We have tested your patent coating for iron surfaces in the most severe way, and we found it impossible to rust the iron where the coating was intact. We consider it is a very valuable invention, and capable of most varied application.

THE CITY OF CARLISLE GAS WORKS (MR. J. HEPWORTH, ENGINEER.)

March 19th, 1879.

The pieces of pipe treated were placed in a humid atmosphere, and I find that they present no change in appearance whatever.

NOTE.—This was twelve months' trial.

FROM MR. J. J. BOWREY, GOVERNMENT CHEMIST, KINGSTON.

KINGSTON, JAMAICA, 11th March, 1879.

DEAR SIR :

Your letter, dated January 18th, reached me too late for me to reply by last mail, and I fear this letter will get to you after, and not before, you read your paper. I arrived here early in May last, and since then the protected iron articles you gave me have been placed as follows : The iron horse has stood indoors at my house, and is as perfect as ever—quite free from rust—and so are the screws and bolts ; these latter have been exposed to the air of my balance room. A pair of ordinary steel scissors,* which have laid on the same shelf as the screws, but wrapped up in tissue paper, are, I now find, a good deal rusted (they were bright when I brought them out, and have not been disturbed until yesterday.) The gate handles and ventilating plate have been the whole time freely exposed to the sky and to the rain and sun. We have

* These were not coated.

had rain at least one day out of two, I think, since May. The handles are free from rust, excepting a few pin points. One handle I broke; of course the broken surfaces have rusted freely. The plate shows a little more rust, but it is on upper sharp angles, where I suspect portions of the protecting film have been broken off by the plate being trodden on. In my balance room I have a slab of polished cast iron on which to cool crucibles, and it has to be polished once or twice a week to keep it free from rust; if exposed to the weather it would be covered with rust in a single rainy day.

I remain, yours very truly,

JOHN JAMES BOWREY.

FROM THE RIGHT REV. DR. STEERE, BISHOP OF ZANZIBAR.

ZANZIBAR, 26th March, 1879.

MY DEAR SIR:

We have had here for over half a year some specimens of your mode of treating iron, and they have kept a good surface, though our climate, being hot and damp, with a constant breeze from the sea, is one in which iron rusts rapidly.

I am, yours ever sincerely,

EDWARD STEERE, *Missionary Bishop*.

FROM MESSRS. JOHN WARNER & SONS, HYDRAULIC AND SANITARY ENGINEERS.

THE CRESCENT FOUNDRY, CRIPPLEGATE, LONDON, }
March 6th, 1879.

The closet pan which you covered for us and which was sent to us in November, 1878, we have exposed to the atmosphere ever since—four months ago. It has been placed so as to be exposed to snow, frost, rain and smoke, and we do not see the slightest appearance of rust or detriment. We have purposely subjected this piece to this particular test in order that we may decide as to the adaptation of the process to some other articles. We are so satisfied that it will be what is wanted for this particular purpose which we have in view, that we have fully decided on the matter, and shall take the opportunity of calling upon you in a few days, when we will fully discuss the arrangements which may be made as to the future.

FROM THE SILBER LIGHT COMPANY, LIMITED.

49 WHITECROSS ST., March 11th, 1879.

We have subjected the lamp stands (nine in number) to an ordinary test, viz: exposure in a damp place, and on examining them a few days ago could trace no apparent alteration in their appearance, and certainly there was not the slightest sign of rust. These were received by us from you on October 22d, 1878.

RESULT OF TESTS OF METAL COATED BY THE BARFF PROCESS.

SIR JOSEPH WHITWORTH & Co., Limited,
24 Great George Street, Westminster.

APRIL 23d, 1879.

DEAR SIR :

SIR JOSEPH WHITWORTH desires me to send you the inclosed copies of the results of tests of metal, which he received this morning from Manchester.

He thinks the trials after being subjected to Prof. BARFF's process, very satisfactory. I am yours most obediently,

JOHN H. R. WINFIELD.

R. BRUDENELL-CARTER, Esq.

February 22d, 1879.

METAL TESTED BEFORE AND AFTER BEING SUBJECTED TO PROFESSOR
BARFF'S PROCESS.

No. of Metal, 603.

BEFORE.		AFTER.	
PRESSURE IN TONS.	ALTERATION.	PRESSURE IN TONS.	ALTERATION.
15	<i>Nil.</i>		
17	"		
18	"	18	<i>Nil.</i>
19	"	19	"
20	"	20	"
21	'0002	21	'0007
22	'0009	12	'0023

April 22d, 1879.

METAL TESTED BEFORE AND AFTER BEING SUBJECTED TO PROFESSOR
BARFF'S PROCESS.

No. of Metal, 433.

BEFORE.		AFTER.	
PRESSURE IN TONS.	ALTERATION.	PRESSURE IN TONS.	ALTERATION.
15	<i>Nil.</i>		
17	"		
18	"	18	<i>Nil.</i>
19	"	19	"
20	"	20	"
21	"	21	.0008
22	'0002	22	.0022
23	'0008	—	—

COPY OF A LETTER FROM F. J. EVANS, ESQ., M.I.C.E., ENGINEER OF THE GAS LIGHT AND
COKE WORKS, BECKTON.

HORSEFERRY ROAD, WESTMINSTER, }
18th May, 1879.

MY DEAR SIR :

I have received the very nice specimen of your process for the production of cast iron, and trust you will succeed in making it a profitable thing, as it deserves to be.

I return you the cast iron dragon you sent me nearly two years since, which has been exposed in the open air all that time, and shows no signs of oxidation ; in fact, it is as perfect as when you sent. I may add that every shower of rain, hail, sleet or snow that fell during that time necessarily wetted every part of it.

Yours very truly,

(Signed)

J. F. EVANS.

FROM MESSRS. SMITH & WELLSTOOD, AMERICAN STOVE MANUFACTURERS, GLASGOW.

4th May, 1880.

We take great pleasure in telling you that, in our judgment, your process for oxidizing the surfaces of iron manufactures is a complete practical success in preventing the slightest appearance of rust. We have had in use and under test in every way we could think of, for the last six months, one of our portable cast iron farm and laundry boilers, (a 22 gallon size) coated by your oxidizing process, and not a sign of the least rust or the slightest discoloration of pure clean water has at any time shown itself, although the said boiler has several times been standing out of use for weeks, with portions of water in it to induce rusting. Another test we have given it, and which satisfies us of its value, is by several times firing the boiler with only a small portion of water in it, thereby exposing all above the water line to a strong heat, and without any perceptible injury to the surface coating, and this is certainly what neither the galvanizing nor the enameling process would stand.

FROM MESSRS. JOHN DEWRANCE & CO.

158 GREAT DOVER STREET, BOROUGH, LONDON, }
July 19th, 1881.

Your favor of the 16th is duly received ; we have much pleasure in stating that we have used Professor BARFF's process for protecting iron from rust for the plugs of our Patent Asbestos Packed Cocks for nearly two years, and have found same most satisfactory in every respect.

FROM MESSRS. CROMAR, SCOTT & CO., LIVERPOOL.

September, 1880.

The tubes have been for over twelve months fully exposed to the fumes of acid, ammonia, etc., incidental to a galvanizing works, and the results have been highly satisfactory.

From the Engineers of the following Gas Companies in 1880:

THE HORNSEY GAS COMPANY.—I have had your tubes for twelve months in an atmosphere most trying to iron work, and they are not affected.

THE CRYSTAL PALACE GAS COMPANY.—I have had some of your tubes laid for upwards of twelve months in ashes, exposed to air and moisture, and except where the coating has been disturbed by violence the tubes do not show the slightest signs of corrosion. It is well known that such ashes have a most destructive effect upon ordinary tubes.

THE NICTHEROY GAS COMPANY IN 1881.—I have uncovered a service laid with tubes coated by BARFF's process which was laid over eighteen months ago, and it is free from rust and as clean as when first laid.

FROM MESSRS. JNO. HARDMAN & CO., ART METAL WORKERS, BIRMINGHAM.

April 27th, 1881.

We have used for over a period of two years the BARFF process, and have found it to fulfill all our requirements. We have had bell-pulls, hinges, etc., exposed to all kinds of weather, and they stand without any apparent change.

FROM MESSRS. HORN, BLACK & CO.

90 GLENGALL ROAD, OLD KENT ROAD, }
July, 15th, 1881.

TO GEO. BOWER, Esq.,

DEAR SIR: In reply to your inquiry we beg to say that we have a furnace in which, without any difficulty, we treat three tons of corrugated iron sheets at a time, and that we have used the sheets thus treated by Professor BARFF's process to a considerable extent during the past year. Our experience assures us that the process is more economical than galvanizing and far more durable.

Yours truly,

HORN, BLACK & CO.

The following medals have been awarded for specimens of iron coated by the BOWER-BARFF process :

GOLD MEDALS.....	<i>Melbourne Exhibition, 1881.</i>
TWO SILVER MEDALS..	<i>Paris Exhibition, 1878.</i>
SILVER MEDAL.....	<i>Society of Arts, 1876.</i>
BRONZE “	<i>Sydney, 1880.</i>
BRONZE “	<i>Yorkshire Fine Art and Industrial Exhibition, 1879.</i>
BRONZE “	<i>Royal Cornwall Polytechnic Society, 1879.</i>

The cost of the process has been materially cheapened, particularly in its application to wrought iron since its adoption in this country, and far better results are being obtained not only in securing a more adherent coating but also in the more beautiful finish.

For interior work the *polished* magnetic oxide surfaces must supplant the plated work which is now so widely used not only on account of its cheapness, but more especially for its great beauty.

The principal applications of the process is to :

Architectural Iron Work.

Art Metal Work, such as Statues, Fountains, Vases, Balusters and Panels.

Bridge and Roof Work.

Builders' General Iron Work, Girders, Joists, Columns, Tanks, Gas, Water and Drainage Pipes.

Castings for Chemical Works.

Carriage and Wagon Iron Work.

Church and other Interior Fittings.

Couservatories.

Culinary Utensils.

Guns and Gun Furniture.

Gun Carriages.

Gates, Railing, Fencing, Garden Requisites, Seats, Flower Stands, Fountains.

Gas Tubes, Brackets and Fittings.

Household Ironmongery—Bedsteads, Baths and Fenders.

Hot Water Pipes and Fittings.

Monumental Iron Work.

Pier, Dock and Lighthouse Work.

Sanitary Appliances.

Pipes, Syphons, Ventilating and Drain Grates.

Stable Fittings.

Ships' Iron Work.

Telegraph Posts and Iron Work.

Tubes (Wrought Iron) for Gas, Water or Steam.

The Company will receive applications for licenses, or will dispose of territorial rights, and will furnish working drawings and estimates.

The fullest facilities are afforded for testing and studying the process at the Hecla Works, where sample lots will be treated free of charge to intending licensees.

Samples must be shipped direct, freight paid, to POULSON & EGER, North 11th and 3d Streets, Brooklyn, E. D., N. Y., and a letter requesting treatment must be directed to the office of the Company at 35 Broadway, New York.

Samples treated in Europe and this country are on exhibition at the Company's offices.

Parties erecting furnaces will be instructed in their management by the Company's engineers.

Address communications to the Company.

NEW YORK, June 1, 1883.



UNIVERSITY OF CHICAGO



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